for the observation of the stars, nebulæ, and Sun, have been constructed by Messrs. Grubb and Son on the very admirable plan of automatic motion for minimum deviation recently described by them in the *Monthly Notices*.

There has not been time, as yet, to do more than make the preliminary observations for the adjustments of the instrument.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

General Remarks.

The progress of Astronomy, in common with that of every other science, has been affected by the terrible war, which has so largely absorbed the attention of all classes since July, 1870. We have been influenced by it in England, but in France and Germany scientific progress has been greatly interrupted. Even before the completion, in September last, of the great cordon of troops and artillery which shut off Paris from the rest of the world, the effects of war on science were shown by the reduced size of the *Comptes Rendus*, and the disappearance of some French scientific journals. In Germany, many young astronomers of great promise, not altogether unknown in this country, exchanged the observatory for the battle-field, where some, alas! have fallen.

But notwithstanding these unfavourable circumstances, the year just closed has not been barren of discoveries. Three planets, hitherto unrecognised, have been added to the known members of the solar system; four comets have been detected, some even in Germany by an observer at no great distance from the scene of war; and an increase of our knowledge of the constitution of the Sun has been undoubtedly obtained from the recent Solar Eclipse, to observe which, two of the greatest astronomical expeditions of modern times were organised and despatched from this country and America to Sicily, Cadiz, Gibraltar, and Oran. In our own Society the evening meetings have been well attended, at which important papers—of which a list will be found on another page—have been read and freely discussed.

The Total Solar Eclipse, Dec. 22, 1870.

As this eclipse would be total at several places within easy reach of England, namely, the south of Spain, Sicily, and the north coast of Africa, it appeared to the Council an occasion on which they should take steps to assist observers, and, if necessary, organise an expedition provided with suitable instruments for attacking the important problem which still remained unsolved,

—the extent and nature of the Coronal Light. At the meeting of Council held in March, the Council resolved itself into a committee to consider the preparations to be made for the observation of the Solar Eclipse of Dec. 22. In the following month this committee united itself with a committee appointed for a similar purpose by the Royal Society. At a meeting held by this joint committee on June 16 it was resolved that the Government be solicited to grant two ships for conveyance of observers to Spain and Sicily, and also a sum of money for the preparation and transport of instruments. To this application, which was made in accordance with former usage, to the Admiralty, an unfavourable answer was received on August 10. Absence from town of some members of the joint committee and other circumstances prevented any further steps being taken until November 4, when the joint committee met and resolved that an application for means of transit for the expedition and for a pecuniary grant in aid of the funds voted by the Royal and Royal Astronomical Societies should be made to the Lords Commissioners of Her Majesty's Treasury. To this renewed application a favourable reply was returned by the Government, who placed H.M. Troop-Ship "Urgent," at the service of the expedition for the conveyance of observers and instruments to Spain and Africa, and the sum of 2000*l.* in aid of the travelling expenses of the overland party to Sicily and for the preparation and transport of instruments.

At this late moment, a few weeks only before the expedition should leave England, the greatest energy was needed to organise a party of observers and procure the special instruments needed for the proposed observations. A small organising committee was appointed, which met almost daily up to the departure of the expedition. The successful and very complete arrangements ultimately made were due in great measure to the unflagging zeal of the secretary Mr. Lockyer and of the assistant-secretary Mr. Ranyard; and the Council wish here to state how much in their opinion is owing to the valuable suggestions and assistance afforded by Prof. Stokes. The opticians, Mr. Browning, Mr. Grubb, Mr. Ladd, and Mr. Slater, afforded very valuable assistance to the expedition by the preparation and loan of instruments, for which they deserve the grateful thanks of the Society.

Distinct observing parties in charge of Mr. Lockyer, Rev. S. J. Perry, Capt. Parsons, and Mr. Huggins, were appointed for the four stations, Sicily, Cadiz, Gibraltar, and Oran. Professor Tyndall accompanied the Oran party as an independent observer.

Lord Lindsay, taking with him several skilled observers and a very complete photographic apparatus, went to Cadiz independently at his own expense.

Besides these English expeditions there was an American expedition, with Prof. Peirce at its head, consisting of two parties, one in Sicily, under Prof. Peirce himself, and one in Spain, under Prof. Winlock. Independent observations were

taken by Prof. Newcomb at Gibraltar, and by a party consisting of Profs. Hall, Eastman, and Harkness, in Sicily.

At no former eclipse have preparations been made on so complete a scale, or the work to be done so skilfully divided among observers trained to carry out efficiently the parts assigned to them. All the parties were prepared to attack the corona by the several methods of the spectroscope, the polariscope, photography, and eye-drawings. With favourable weather it was not too much to expect from these expeditions a searching and almost exhaustive examination of the coronal light by these different methods of attack.

The weather was not propitious; at all the stations the sky was more or less obscured by clouds. On the African continent, where there had been grounds for confidently anticipating a cloudless sky, the English party and M. Janssen, who had escaped with his instruments from Paris in a balloon, at Oran, and Drs. Weiss and Oppolzer at Tunis, saw nothing of the eclipse at the time of totality, though the earlier phases were visible at Oran.

At Cadiz and in Sicily successful photographs of the totality were obtained by Lord Lindsay, Mr. Willard, of the American Expedition, and Mr. Brothers. At these stations, and also at Estepona, some observations were obtained of the spectrum and polarization of the corona.

Although the gain to our knowledge of Solar physics is much less full and decided than doubtless it would have been if the very efficiently equipped and competent observers had been favoured with a cloudless sky, the new information which comes to us from the eclipse is very valuable, and well repays the large amount of thought, time, and money, which were so freely bestowed upon the preparations.

The present time is too early for a complete analysis of the different observations with a view of eliciting from them the new teaching which they may contain of the extent and nature of the coronal light, still it may not be undesirable to give a short account of some of the more important observations.

In the last Annual Report, in the account of the Eclipse of August, 1869, attention was called to the two apparently distinct portions besides the prominences in the light seen round the Moon during totality. The American pictures showed similar indications of brighter portions near the Sun's limb, within which the eruptions of hydrogen forming the prominences take place, to those which were visible in the photographs taken by Mr. De La Rue in 1860, and by Major Tennant and Dr. Vogel in 1868. A distinction between different portions of the coronal light was observed as early as 1706 by MM. Plantade and Capiés at Montpelier. "As soon as the Sun was eclipsed there appeared around the Moon a very white light forming a corona, the breadth of which was equal to about 3′. Within these limits the light was everywhere equally vivid, but beyond the exterior contour it was less intense and was seen to fade off gradually into the surrounding darkness, forming

an annulus around the Moon of about 8′ in diameter." In 1842 M. Arago considered this distinction to be sufficiently marked to sanction the subdivision of the corona into two concentric zones, the inner zone equally bright and well defined at the outer border, while the exterior zone gradually diminished in brightness until it was lost in the surrounding darkness.

The observations of the eclipse of last December confirm these earlier descriptions as to the apparent subdivision of the coronal light, though the breadth of the inner zone varies considerably as described by different observers. In our future remarks we shall restrict the word *corona* to the inner brighter ring, and for the faint exterior portion use the term *halo*.

It may conduce to clearness in our interpretation of those observations which appear to differ from each other, if we consider that the imperfect transparency of our atmosphere must cause a scattering of a portion of the light of the corona seen through it, and form a more or less brightly illuminated screen between the eye and the eclipsed Sun. This atmospheric light will interfere especially with the observer's appreciation of the form and extent of the faint halo. There may exist at least three distinct sources of the light seen about the Sun, in addition to the prominences, the corona, a solar halo overlapping the corona or beginning at its exterior limit, and an atmospheric halo produced by the scattering of the light by our atmosphere. The corona and solar halo would probably not alter greatly in the short time between observations of the same eclipse at different stations, but the scattering of light would be peculiar to each station, and be mixed up with the effect of haze or light cloud present at the time. It is *possible* that without the Earth's atmosphere, some scattering of light may arise from the imperfect transparency of interplanetary space, not to speak of the possible existence of finely divided matter more densely aggregated in the neighbourhood of the Sun. It may be that in these and some other considerations will be found the key to the interpretation of the widely different descriptions of the solar surroundings which come to us from different observers.

Prof. Watson observing at Carlentini describes a bright corona about 5′ high, observations at Cadiz give a breadth of about 3′; Lieut. Brown observing with Lord Lindsay found the inner zone which he saw defined at its outer margin to vary from 2′ to 5′ in breadth. Mr. Abbatt at Gibraltar at about 5′ high. Some of the observers describe the exterior contour of the corona to be affected by the prominences bulging out over the loftiest of these. In the photographs a defined zone is also seen,—in Lord Lindsay's photographs and the one taken by Mr. Willard, it extends rather more than 1′. In the photograph by Mr. Brothers the height of the brighter zone varies from 3′ to 5′.

We will now speak of the photographs of the totality, which are very instructive.

The photographs taken at Cadiz by Lord Lindsay were ob-

tained by placing the sensitive surface at the focus of a silvered glass mirror $12\frac{1}{4}$ inches in diameter and 6 feet focal length, giving an image of the Sun about $\frac{3}{4}$-inch in diameter. The other photograph taken near Cadiz by Mr. Willard of the American expedition, was obtained at the focus of an achromatic object-glass of 6 inches diameter, specially corrected for actinic rays.

Mr. Brothers, at Syracuse, employed a photographic object-glass of 30-inches focal length and 4 inches diameter, lent to him by the maker, Mr. Dallmeyer.* This lens gave a brilliant image of the Sun about three-tenths of an inch in diameter, which was received upon a plate 5 inches square. The camera was mounted on the Sheepshanks equatoreal, belonging to the Society.

The photograph taken at the commencement of totality by Lord Lindsay had an exposure of twenty seconds. It shows around the Moon's advancing limb a bright corona extending about 1′ from the Moon's limb, in which the prominences are distinctly marked, and outside this a halo of faint light diminishing rapidly in brilliancy with indications of a radial structure which can be traced as far as 15′ from the Moon's limb. On the other side of the Moon, where it overlaps the Sun sufficiently to conceal the prominences and the bright corona, *the halo is almost absent.* It may be suggested that such portion of the halo as appears around the advancing limb of the Moon has its origin on this side of the Moon. As a pure speculation the explanation may perhaps be hazarded, that the true solar halo, as some spectroscopic observations would suggest, was less powerfully actinic than the scattered light of the prominences and corona, in which the halo on the one side of the Moon only as seen on the plate may have its origin.

The photograph taken by Mr. Willard was exposed during a minute and a half, and therefore must contain mixed up several successive appearances. The prominences are distinctly shown, and a defined corona of rather more than 1′ in height. In the halo there are indications of portions of unequal brightness, and a radial structure, but the most remarkable feature is a V-shaped rift or dark space in the halo on the south-east, beginning from the outer boundary of the bright corona, a second similar dark space is faintly traceable on the south. The same dark gaps are also recorded in an eye-sketch by Lieut. Brown. Similar dark rifts are also shown in Mr. Brothers' photograph taken at Syracuse. The photograph taken by Mr. Brothers is very valuable, since it shows the halo extending towards the north-west, about two diameters of the Moon, and on the east and south about one diameter, the halo, therefore, is not concentric with either the Sun or Moon, but extends to the greatest distance in the direction from which the Moon is moving. It shows in many parts traces of a radial structure. The stronger light about the Moon is much broader on the west and north-west, and assumes a somewhat stellate

* These lenses are constructed by Mr. Dallmeyer for photographic copying.

appearance with rays gradually softening down as if combed out into the fainter halo. This photograph was taken in eight seconds, from the 93rd to the 101st second after the commencement of totality, and therefore presents a true representation of the different phenomena at the time, that is, as regards their relative actinic power which may possibly differ in a sensible degree from the relative brightness they present to the eye. The eye-sketches made at different stations show remarkable differences, especially in the form of the outer part of the halo; some represent it as consisting of separate rays, others give to it an almost true geometrical contour; in some of the Spanish sketches a tendency to assume a roughly quadrangular form can be detected, while in most of the Sicilian drawings there is a tendency to an annular form.

We pass to the spectroscopic observations of the corona and halo.

Prof. Winlock, using a spectroscope of two prisms on a five and a half inch achromatic, found a faint continuous spectrum. Of the bright lines, the most persistent was 1474 Kirchhoff. This bright line, and the continuous spectrum without dark lines, were followed from the Sun to at least 20′ from his disk. Prof. Young estimates the least extension of this line to a solar radius.

Capt. Maclear, observing with a direct vision spectroscope attached to a four-inch telescope, saw a faint continuous spectrum and bright lines in positions about C D E and F to a distance of 8′ from the Moon's limb, and also the same lines, but much fainter, *on the Moon's disk*. This observation would seem to show, as has been already suggested, that some of the light from the true surroundings of the Sun is scattered by some medium between the eye and the Moon, and therefore the distance from the Moon to which these lines can be traced does not imply necessarily an equally great extension of the true halo.

Lieut. Brown, of Lord Lindsay's party, saw only a continuous spectrum without bright lines, from $4\frac{1}{2}'$ to $25'$ from the Moon's limb. Mr. Carpmael, observing at Estepona, saw three bright lines in the spectrum of the corona. He considers the one in the green to correspond with 1359 Kirchhoff.

The observations with the polariscope show that a portion of the coronal light is polarized; and though the results as to the plane of polarization are interpreted differently by different observers, there seems reason to suppose with Mr. Ranyard and Mr. Peirce that the light is polarized radially, showing that the corona and halo may possibly reflect solar light as well as emit light of their own.

There is one observation made by Prof. Young which is of so much importance that it will be well to give an account of it in Prof. Langley's words:—

"With the slit of his spectroscope placed longitudinally at the moment of obscuration, and for one or two seconds later, the field of the instrument was filled with bright lines. As far as could be judged, during this brief interval every non-atmospheric line

of the solar spectrum showed bright; an interesting observation confirmed by Mr. Pye, a young gentleman whose voluntary aid proved of much service. From the concurrence of these independent observations we seem to be justified in assuming the probable existence of an envelope surrounding the photosphere, and beneath the chromosphere, usually so called, whose thickness must be limited to two or three seconds of arc, and which gives a discontinuous spectrum consisting of all, or nearly all, the Fraunhofer lines showing them, that is, *bright* on a dark ground."

Rapid and imperfect as this early sketch must necessarily be of the observations of the last eclipse, it shows a distinct and important gain to our knowledge of solar physics.

Spectrum Analysis.

In the winter of 1867–8 Angström found the light of the auroral arch to be nearly monochromatic, giving in its spectrum a single brilliant line in the green near the group of calcium lines, and traces of three feeble bands near F. This observation was confirmed by Struve in 1868. In 1869, Prof. Winlock observed five bright lines in the green and blue parts of the auroral spectrum.

During the past year a brilliant line in the red portion of the spectrum has been detected in some parts of the auroral display. This line was observed first by Mr. Ellery at Melbourne, on April 5, 1870. "The red streamers," he writes, "were gorgeous, and emitted light enough to read a newspaper by. The most remarkable and brightest of the lines in the spectrum was a red line more refrangible than C; a greenish band or two in the position of the green calcium lines, and a cloudy band more refrangible, appeared as if irresolvable into lines. The dark segment rested on the sea-horizon. Above this was an arch of greenish auroral light, and from a well-defined boundary of this the rose-coloured streamers started zenithwards. The red line disappeared immediately the spectroscope was directed to any point below this boundary, and only the green lines remained. The loss and reappearance of the red line was as sharp as possible as the slit passed from the red to the green region."

On October 25 Zöllner compared the position of the red line with the lines of lithium and sodium. From the position of the auroral line relatively to these, he considers that it falls in the spectrum very nearly where a group of atmospheric lines occurs in the solar spectrum having a mean wave-length of 0·0006279. Zöllner suggests that this auroral spectrum, which does not correspond with any known spectrum of the gases of the atmosphere, may be a spectrum of one or more of these gases of an order we have not yet been able to obtain experimentally, since we can have to do only with thin strata of gas, whereas the auroral light may come from an enormously thick layer of one or more of the gases of the atmosphere at a relatively low temperature.

Our Fellow, Mr. Lockyer, in continuation of his important researches on Solar Physics, considers that he has now evidence, from the different behaviour of the line C and the line near D, that the latter does not belong to hydrogen—a result in harmony with the absence of the line near D, from the different spectra of hydrogen obtained experimentally.

His observations show, he believes, that prominences may be divided into two classes,—those in which great action is going on and lower vapours injected, and those which are tranquil so far as wave-length goes, which are usually high, bright, and persistent.

While observing a solar spot with the spectroscope, on April 16, Mr. Lockyer saw "the whole prominence spectrum was built up of single discharges shot out from the region near the limb, with a velocity sometimes amounting to a hundred miles in a second. On the following day, using a tangential slit, he found "in the spectrum of the base of the prominence hundreds of the Fraunhofer lines beautifully bright." Mr. Lockyer considers that he has evidence that at the present maximum period of sun-spots not only is the region of a spot comprised by the penumbra, but the chromosphere also is shallower than in the year 1868.

Prof. C. A. Young has succeeded, by means of a spectroscope having a dispersive power of thirteen prisms of heavy flint each with an angle of 55°, attached to an achromatic telescope of 6·4-inches aperture, and 9 feet focal length, in obtaining photographs of the solar prominences. Negatives have been made which show clearly the presence and general form of the protuberances, but at present the definition of details is unsatisfactory. The hydrogen line γ (2796 of Kirchhoff), though very faint to the eye, was found to be decidedly superior to F in actinic power.

On Sept. 14, Prof. Young saw a very brilliant small fragment detach itself from a prominence, enlarging in size, and growing fainter as it rose. It disappeared in $12\frac{1}{2}$ minutes at a distance of 2′ 30″ above the limb of the Sun. Allowing for the obliquity of motion to the parallel of declination, the length of path passed over by this cloud was more than 90,000 miles, with a velocity of above 120 miles per second.

Prof. Young observed on Sept. 27 a prominence formed of separate, well-defined narrow streamers, which appeared to consist of matter first violently ejected and then as violently deflected by some force acting nearly at right angles. He says:—"I am unable to see how any mere projection from the Sun could have produced such a form, and cannot help feeling that it indicates a something in which powerful currents may exist, even at such great elevations above the solar surface. In short, an atmosphere extending far beyond the limits which calculation would seem to assign as possible."

Prof. Young calls special attention "to a bright line 2581·5, Kirchhoff, the only one of my list which is not given on Mr. Lockyer's. This line, which was conspicuous at the eclipse, 1869, seems to be always present in the spectrum of the chromosphere,

and shows the form of its upper surface or of a protuberance nearly as well, though, of course, not so brightly as the line 2796. It has no corresponding dark line in the ordinary solar spectrum, and not improbably may be due to the same substance that produces D."

Professor Respighi has done good service in the same field of research by mapping all the prominences which appear around the Sun from day to day, and arranging them for each day in a straight line, so that the appearances for different days by being placed under each other admit of easy comparison. From the conclusions to which this method of studying the forms of the prominences has led him, we may select one or two. "The prominences are less active, less frequent, and less developed at the equator than towards the poles, while in the circumpolar regions great protuberances are not met with, but only very small, temporary flames,—the prominences seem to be, therefore, in connexion with the spot-zones, and possibly to be influenced by the solar rotation." "The difference of duration of the prominences is very great, while some develope and disappear in a few minutes, others remain visible for many days."

Mr. J. H. Hennessy, to whom a spectroscope was intrusted by the Royal Society for observations of the atmospheric lines of the Solar Spectrum at different altitudes of the Sun at the favourable position of Mussoorie, has sent in a first report of his observations, together with a chart of the atmospheric lines, as seen by him at sunset. This map has been printed in the *Proceedings of the Royal Society*, and may be found of assistance to those who are studying these lines.

Valuable additions have been made during the past year to the apparatus employed in spectroscopic research. The most important of these doubtless are improved methods by which the prisms of a spectroscope can be brought automatically to the position of minimum duration for any part of the spectrum to which the observing telescope is directed. By such an arrangement the spectrum is rendered more nearly normal with respect to the relative extension of the different colours, but the most important advantage is the greater brightness of the spectrum, precisely where light is most needed, towards the violet and red limits of the visible spectrum, in consequence of the whole of the light from the collimator being enabled to reach the observing telescope. Instruments possessing these advantages in a greater or less degree had been constructed by Littrow, Rutherford, Prof. Young, and Mr. Lockyer. We must refer to the *Monthly Notices* for a description of independent methods by which this important addition to the spectroscope has been successfully accomplished by Mr. Browning and Mr. Grubb, and for the valuable suggestions contained in a paper by Mr. Proctor.

Attention may also be called to new forms of registering spectroscopes constructed for recording rapidly the positions of lines which might be seen during observations of the late solar eclipse. Professor Winlock contrived a form of instrument in which the positions of the observing telescope when directed to different parts of the spectrum are recorded by marks upon a plate of silvered copper.

In an instrument constructed by Mr. Grubb at the suggestion of Mr. Huggins, the observing telescope is fixed, and a pointer placed at its focus can be brought rapidly to any part of the spectrum by a quick motion screw, a positive eye-piece being used, which is movable, so that the line under observation can be brought into the middle of the field. The arm carrying the pointer is connected by a lever with a second arm carrying two needles, which pass over a card contained in a frame, which may be brought successively into five new positions, for the record of as many spectra. By pressing a finger on one of the needles, a prick on the card records the position of the line. If the line is bright, the second needle is also pressed, by which a second prick is made below the one recording the position of the line, and in this way a bright line is distinguished from dark lines which may have been recorded.

The Minor Planets.

Three minor planets have been discovered within the last twelve months, *Lydia* (110) at Marseilles, by M. Borelly, on April 19; *Ate* (111) at Hamilton College, Clinton, New York, by Dr. C. H. F. Peters, on August 14; and *Iphigenia* (112) also by Dr. C. H. F. Peters, on September 19. The mean distance of each from the Sun, assuming the radius of the Earth's orbit = 1, is for *Lydia* 2·693, *Ate* 2·576, and *Iphigenia* 2·436. The three new members are therefore included among those composing the innermost portion of the asteroidal ring between *Mars* and *Jupiter*. The mean distance of *Flora*, the nearest of the minor planets, is 2·201, and that of *Sylvia*, the most distant, is 3·494.

The *Berliner Jahrbuch* for 1873 contains a supplement giving approximate ephemerides for 1871, at 20-day intervals, for 108 of the minor planets. The places are sufficiently accurate for finding them with the equatoreal. Daily ephemerides for 58 are also given when the planets are near opposition. As astronomers have now to rely, with few exceptions, on the *Berliner Jahrbuch* for the tabular places of the minor planets, it would be very advantageous to meridional observers if errors of the ephemerides were published in the *Monthly Notices* or the *Astronomische Nachrichten* as soon as possible after equatoreal observations have been made. The identification of the smallest of these minute objects is always a matter of difficulty when observed in a telescope with a field full of objects of a similar magnitude.

The minor planets continue to be systematically observed at

Greenwich, Paris, Königsberg, Leipzig, Leyden, Washington, the Observatory of Hamilton College, Clinton, New York, and a few others. Since the closing of Paris by the siege, they have been observed at Greenwich throughout the lunation when practicable, instead of only during the period from new to full Moon. The very cloudy weather of the last few months has, however, very seriously interfered with this class of observations.

Recent numbers of the *Astronomische Nachrichten* contain detailed investigations of the orbits of *Thalia*, *Polyhymnia*, and *Euphrosyne*, by Mr. Schubert, of the American Nautical Almanac Office, to whom Astronomy is already indebted for many similar researches. M. Oppolzer has also contributed a paper on the Orbit of *Olympia* (*Elpis*), in which he has availed himself of all the observations of that planet made since its discovery in 1860.

Discovery of Comets.

The following comets have been under observation since the date of the last Report. Three of them were detected by our Associate, Dr. Winnecke, whom the Council are glad to see restored to active work after his long illness.

1. Comet I. 1870, discovered by Dr. Winnecke, at Carlsruhe, in May 29.
2. Comet II. 1870, discovered by M. Coggia, at Marseilles, on August 28.
3. Comet III. 1870 (Periodic Comet of D'Arrest), detected by Dr. Winnecke, on August 31.
4. Comet IV. 1870, discovered by Dr. Winnecke, on November 23.

All these comets have been well observed, especially at the German observatories. The elements of their orbits, as well as the separate observations, have been published in the *Astronomische Nachrichten.* Some observations of Comet II. 1870, by Mr. Joynson, are inserted in the *Monthly Notices* for December.

The New Zenith Sector of the Indian Survey.

The zenith sector constructed by Messrs. Troughton and Simms from the designs of Colonel Strange, alluded to in the last Annual Report as having been forwarded to India, has been practically tested by observations of stars in the ordinary routine work of the Indian Great Trigonometrical Survey. After the scrupulous attention given by Colonel Strange to every detail required in the construction of the instrument, some of which were of a novel character, it must be very gratifying to him and also to those who inspected the sector before it left England, to find that the promise of good work given by the preliminary trials at the observatory of the Indian Store Department, has been fulfilled to the satisfaction of the observer, Captain Herschel, by whom the observations in India have been made. As an

illustration of the general accuracy of the determinations of absolute latitudes by the use of the new zenith sector, Captain Herschel remarks that one night's observation (of thirty-six stars in six hours) is amply sufficient to give a resulting latitude, of which the probable error is not greater than $0''\cdot2$. Referring to a recent determination described in a communication to Colonel Strange, he further remarks that "at the last station twenty-two stars out of the list were *Nautical Almanac* stars, so that the latitude was easily deducible. Cutting out *Procyon*, which has a large proper motion, and, I suspect, an erroneous place; and γ' *Virginis*, which has almost certainly an erroneous place, due to confusion of the two components, the remaining twenty give latitudes all falling within a range of $1''\cdot6$." Captain Herschel is of opinion that this satisfactory agreement is due entirely to the great stability of the instrument, and not to any unusual skill on the part of the observer. The Council have great pleasure in congratulating Colonel Strange on the success attending the active employment of this the first of the two proposed zenith sectors to be furnished for the use of the Indian Survey, the construction and examination of which occupied his attention for a considerable time. There seems but little doubt that in their new zenith sector, the officers of the Indian Survey possess a sensibly perfect field instrument for the determination of terrestrial latitudes, and for other geodetical purposes.

The Graphical Construction of a Solar Eclipse.

Among the many valuable astro-mathematical investigations for which the Society is indebted to Prof. Cayley, that on the Graphical Construction of a Solar Eclipse is not the least important. In addition to a complete theoretical discussion, explaining every detail connected with the subject, an example is appended to show that the method can be adapted to practical use. Prof. Cayley has chosen for his example the eclipse of the Sun of December 21–22, 1870. Taking the times and places of the beginning and end of the eclipse, it appears that the error from his construction amounts only to $1\frac{1}{2}$ minute of time and about $1\frac{1}{2}$ degree of place. Prof. Cayley, however, considers that a far greater accuracy than this might be obtained, if a more complete blank projection had been employed by him, and more care taken consequently in the construction. If this were done, then there is but little doubt that a diagram of an eclipse could be constructed which would bear a favourable comparison with the diagrams inserted in the eclipse section of the *Nautical Almanac*.

Mr. Proctor's New Star-Atlas.

For the use of an astronomical instrument a star-catalogue is absolutely necessary; but when an acquaintance with the

separate constellations, or with the general configuration of the principal stars is desired, recourse must be had either to a globe or to a good star-atlas. The valuable star-charts which have been published within the last thirty years, such as those of Argelander, Chacornac, Dien, the Berlin maps, and Mr. Bishop's charts, are useful only to the astronomer who is in the habit of comparing for special purposes the small stars in the field of his telescope with their recorded positions in the chart. These representations of the heavens include stars down to the ninth magnitude, while in special districts of limited extent stars no brighter than the minor planets have been entered. For reference to the relative positions of the brighter stars, however, these charts help us little; and it was to supply this want that our indefatigable Fellow, Mr. Proctor, published in a series of twelve maps a representation of the heavens arranged in such a manner as to exhibit, without sensible distortion of the constellations, all the stars contained in the British Association Catalogue, all the nebulæ in Sir John Herschel's catalogue down to the order marked very bright, all the binaries and suspected binaries in Mr. Brothers' catalogue; all the objects in Admiral Smyth's Celestial Cycle; all the red stars contained in Dr. Schjellerup's catalogue; and, finally, all the recognised variable stars. Two index-plates are also given in which the constellation-figures are inserted.

The maps were drawn originally on the scale of a 30-inch globe, and subsequently reduced by Mr. Brothers, of Manchester, by photo-lithography. Although there is a want of that finish which a professional lithographer would probably have given to the lines and writing, yet that is of small moment in comparison with the preservation of accuracy obtained by the use of photography. The maps are, therefore, exact copies, on a reduced scale, of Mr. Proctor's work as performed by his own hand. The work is dedicated to the memory of our late esteemed President, Admiral Manners.

The Orbit of α Centauri.

The brilliant binary of the southern hemisphere, *α Centauri*, has occupied the attention of observers, at intervals, from the date of Feuillée's observation at Lima, in July 4, 1709, to the present time, either in observations for the investigation of its annual parallax, or for the determination of the elements of its orbit. Recently Mr. E. B. Powell, of Madras, has published revised elements of the orbit of *α Centauri*, determined from a series of recent observations made by himself at a favourable part of the stellar orbit, when the extremity of the perspective ellipse corresponded to the lesser maximum of distance. Mr. Powell is so well satisfied with his observations and deductions as to remark:—'Now, however, though even four or five additional years will enable us to improve the orbit, especially as to the time of periastral passage, the results I have arrived at undoubtedly approxi-

mate *pretty closely* to the truth." From one hundred observations on thirteen nights the angle of position for the epoch 1870·1 was found to be 20°·27′, and from 162 observations on twelve nights, the angular distance equalled 10″·24. The computed period of revolution is 76·25 years. It is the intention of Mr. Powell to lay the complete details of these observations before the Society in a future paper.

Distribution and Distances of the Fixed Stars.

There is no section of astronomical speculation more fascinating than that relating to the probable laws which have governed the distribution and relative distances of the stars. The late Professor Struve, in his remarkable and classical treatise *Etudes d'Astronomie Stellaire*, put forward a general theory founded upon an investigation of the stars observed by Bessel in zones, and catalogued by M. Weiss. The general conclusions of M. Struve were accepted by the principal astronomers as a theory reasonable and probable, although the application of his theory was necessarily liable to some irregularities. So great was the approval of M. Struve's speculations on the relative distances of the stars, which were classified by him into groups, according to magnitude,—stars of the first magnitude being the first group and the nearest to our solar system,—that his results were adopted in many subsequent stellar investigations, especially by the Astronomer Royal, in his first paper on the "Movement of the Solar System in Space," and also in the second, which was written at his request by Mr. Dunkin.

Since the publication of the theoretical conclusions of the two Herschels and Professor Struve, the subject has remained somewhat in abeyance till Mr. Proctor, during the construction of some of his star-maps, was impressed with certain apparent laws of stellar distribution and aggregations, presented by the stars visible to the naked eye. He believes that if a systematic study of the general distribution of the smaller stars were made, still more remarkable laws of aggregation would be probably revealed. For example, if the 310,000 stars contained in Argelander's charts were mapped upon the interior surface of a hollow globe, together with all the known nebulæ, the results of Herschel's star-gauges, and an accurate representation of the Milky Way and Magellanic Clouds, a larger amount of light would be thrown on the relations between the members of the sidereal system than could be obtained by direct observation, even with the most powerful instruments.

Among the numerous papers read before the Society during the last year by Mr. Proctor, two on this subject may be referred to. The first is entitled, "On the Resolvability of Star-Groups, regarded as a test of Distance;" and the second, "The Laws according to which the Stars visible to the naked eye are distributed over the Heavens." In the first of these papers,

Mr. Proctor expresses an opinion that the mere clustering aggregation of unresolved stars is no evidence that the cluster is at a relatively immense distance. He supposes such a cluster to consist of a number of stars all equal in magnitude, and separated from each other by equal intervals, so that each star could be recognised. If the cluster were rapidly swept away into space, the distances between the stars would become smaller as the group gradually disappeared. If the intervals became too small to be distinguished, and the stars remained visible, the result would be a nebulosity. But, on the contrary, if the distances between the stars were sufficiently great to permit each to be seen separately at the moment of disappearance, then the cluster could never become nebulous. Mr. Proctor, therefore, remarks, "that the nebulosity of a star-group whose members are equal and equally distributed, is a question not of distance merely, but of constitution, of the relation between the size and brightness of the constituent orbs and the distances which separate them from each other."

The second paper discusses the relative distribution of the visible stars over the heavens. Mr. Proctor has divided the celestial sphere into areas of different dimensions, the largest being $\frac{6}{11}$ of the area of the hemisphere, and the smaller $\frac{1}{62}$ part, the latter being the gaps or lacunæ in the Milky Way. A very rich region of lucid stars covers *Cygnus*, *Cepheus*, *Ursa Minor*, and *Lacerta*, in the northern hemisphere, while a corresponding rich region covers the keel of *Argo Navis* in the southern hemisphere. But the richest region to be found in both hemispheres is the Milky Way. From a consideration of the comparative number of lucid stars contained in each of the thirteen regions into which Mr. Proctor has divided the heavens, he shows that among the lucid stars special laws of aggregation and segregation exist; and as the lacunæ in the Milky Way are exceptionally bare, while the Milky Way itself includes the richest region of lucid stars, "the fact seems," says Mr. Proctor, "to dispose beyond all question of the theory that the stars forming the milky light of the galaxy (regarded as a whole) lie at vast distances beyond these lucid stars."

Although the Council are not at present in a position to offer any opinion on the stellar speculations which Mr. Proctor has brought before the Society, yet they acknowledge the originality of thought which has been exhibited in these and other papers by him on the probable constitution of the universe.

Dunsink Observations.

During the past year the Astronomer Royal for Ireland has published a report of his observations from 1868 to 1869 with the South refractor. The object-glass of this instrument, $11\frac{3}{4}$ inches diameter, was the gift of the late Sir James South. The

lens was mounted equatorially by Messrs. Grubb and Son in in a very convenient observatory in 1868. The first paper in Dr. Brünnow's report contains a new investigation of the parallax of *α Lyræ*. This investigation rests upon a number of observations of the distance and angle of position of the small companion, the parallax obtained represents therefore the difference of the parallax of the two stars; but as the small star does not participate in the proper motion of *α Lyræ*, Dr. Brünnow considers that its parallax, if it could be taken into account, probably would not alter the parallax assigned to the large star by one hundredth of a second. The value of π comes out $+0{\cdot}2143$ with a probable error of $\pm 0{\cdot}0095$. Dr. Brünnow intends to check this result by the method of observing differences of declination.

The second investigation consists of the determination of the parallax of 61 *σ Draconis* from comparison with a star of the tenth magnitude which is situated 1′ north, and follows it at $1^m\ 52^s$. The result comes out $\pi = +0{\cdot}225$ with a probable error of $\pm 0{\cdot}0279$. As this value is derived from comparison with only one star, it is possible, though by no means likely, that the periodical variation of the observed differences of declination may not be really due to parallax, but may be attributable to some unknown cause, having nearly the same period which affected the instruments. Dr. Brünnow is engaged in an additional series of observations which will remove any doubt which might arise on this point.

The report, which contains in addition to these investigations a table of micrometrical measures of double stars and a description accompanied by plates of the newly erected refractor and observatory, does great credit to the industry and zeal of the Dunsink astronomer.

Heat of the Moon.

Lord Rosse has continued successfully his research on the heat of the Moon, and has confirmed his earlier observations of which some account appeared in the last Annual Report. He now finds the percentage of the Moon's heat transmitted by a plate of glass to be 12, while the same plate gives passage to 87 per cent of the solar heat, and only 1·6 per cent of the heat from a body at a temperature of 180°. In these experiments on lunar radiation as the quantity of heat measured by the thermopile represents the difference between the radiation of a circle of sky containing the Moon's disk and a circle of equal diameter of neighbouring sky, the absolute temperature of neither the Moon nor the sky is obtained. In order to obtain information on these points, Lord Rosse has endeavoured to connect the radiation of the sky with that of a body of known temperature, his observations for the apparent temperature of the sky give values varying from 16° to 31°.

Lord Rosse finds that within a limited range of altitude the

heating power of the Moon's rays appears to diminish with the altitude only about one third as fast as the intensity of the solar chemical rays, as ascertained by Roscoe and Thorpe. The Moon's light was observed to diminish with the altitude in the proportion of three to one, but the lunar heat in the proportion of about five to one. As far as can be ascertained from these observations, the maximum of heat seems to occur a little after full Moon.

Colour of Jupiter.

During the last and present oppositions of *Jupiter* colours and markings have been observed on its surface, especially on the belts, by Mr. Browning, and by Dr. Mayer, of Philadelphia. Browning suggests that the coloured appearances may be of a periodic nature; it is hoped therefore that as *Jupiter* is now nearly at its greatest north declination, and peculiarly favourable for observation in these latitudes, that a systematic scrutiny of its surface will be undertaken by observers in possession of telescopes of superior optical power. It will be very important to have careful and trustworthy delineations of the planet's disk made from time to time, so that materials may accumulate for the comparison of the appearances of the planet at different epochs.

Royal Observatory, Cape of Good Hope.

Many of the Fellows are aware that Sir Thomas Maclear has resigned the office of Government Astronomer at the Cape of Good Hope, in consequence of declining health, and that the vacancy has been filled up by the appointment of our late valued Secretary, E. J. Stone, Esq.

In the face of the large accumulation of unreduced observations, it appeared to Mr. Stone necessary to somewhat restrict the observing with the transit circle. The observations of stars near the pole had been somewhat confined to close circumpolars. It appeared desirable therefore to extend these observations to stars further from the pole for a check upon the accuracy of the refraction tables employed and the colatitude adopted. It has been thought also that this extension of zero points near the South Pole may be valuable for many purposes, and amongst others for the adjustment of instruments in 1874. A series of such observations has been in progress since October and will be continued for some time. With the present year a systematic reobservation of Sir John Herschel's Cape observations of double stars has been commenced. This will not throw much additional computing labour upon the staff. The first aim of the staff will be to bring forward as soon as possible a standard catalogue of stars, observed with the great transit circle during the years 1856 to 1864. The reductions of the observations made in 1856 have been completed, and it is hoped that the results will shortly be

in the hands of astronomers. The catalogue will contain the places of 328 stars, all well observed. Great praise is due to the assistants generally, but more particularly to Mr. Mann, for the energy with which the somewhat uninteresting and irksome labour of bringing up the heavy accumulation of back work is now being pressed forward.

The vigour with which Mr. Stone has commenced the examination of the great mass of arrears of computations, gives the Council every reason to hope that we shall soon have a standard catalogue of southern stars observed with an instrument comparable with the Greenwich transit circle.

Argentine National Observatory.

The Fellows will receive with gratification the intelligence that an addition has been made to the comparatively small number of astronomical observatories in the Southern hemisphere, and that the new establishment has been placed under the able directorship of our Associate, Dr. B. A. Gould. The Argentine Congress having voted the foundation of a National Observatory at Cordova ($31\frac{1}{2}°$ South latitude), Dr. Gould was invited by the Minister of Public Instruction to organise and take charge of it, pursuing such a scheme of observations as he considered most desirable. Dr. Gould came to Europe in the spring of the past year to procure instruments and books, and went to Cordova in the course of the summer, taking with him four assistants. His first aim will be to extend the survey of the Southern heavens from the limit reached by the zone observations of Argelander (30° S. Decl.) towards the limit of certain as yet unreduced zone observations made by the late Commander Gilliss, extending to about 30° South Polar Distance. All stars down to the ninth magnitude will be included in this survey, and their positions will for the present be made to depend upon the standard star-places determined by Dr. Gould, which form the basis of those given in the American *Nautical Almanac*. Physical observations will be undertaken as far as may be consistent with the energetic prosecution of the before-mentioned task. The Observatory is, or will be, furnished with a Repsold Meridian Circle of $4\frac{1}{2}$-inches aperture, an equatoreal of 11 inches aperture, a spectroscope, and a Zollner's astrophotometer.